The Protection and Decoration of Concrete

Maximilian Toch

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The Protection and Decoration of CONCRETE

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The Protection and Decoration of CONCRETE

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PREFACE

WITH the exception of articles published by the American Concrete Institute written by various chemists, including myself, and short references in the chemical literature, there is no comprehensive treatise which covers the subject of painting and decorating Portland Cement concrete in a scientific manner. I have been urged on several occasions to write a short book on this subject.

Inasmuch as many men interested in concrete construction will probably read this book, who are not interested in any lengthy tabulated details of tensile and compressive strengths, I have purposely avoided long drawn out statements on that topic. I have attempted, rather, to classify the use of certain pigments as either increasing or decreasing compressive and tensile strengths, or as having little or no

effect. I believe this much better than burdening the reader with details.

The numerous deleterious and beneficial colors which can be added to Portland Cement have been classified in accordance with their composition so that even the man who is not scientifically or technically trained can ask for material which he knows will not injure the resulting structure.

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Painting and Decorating Concrete

PORTLAND CEMENT concrete, as we know it, was invented in 1824. Up to the beginning of the twentieth century it was accepted as a fact that no paint would stick to concrete and therefore it was futile to attempt it. This was true because up to the beginning of the twentieth century there were no other paints except linseed oil paints and linseed oil is saponified when it comes in contact with moist concrete.

With the discovery of the use of China wood oil and the resins that are essential in its treatment, it became possible to paint concrete floors and concrete interiors so that the coatings would not only keep out water but they would adhere and form a sightly surface. The first patent for the successful manufacture of a protective and decorative coating for the

interior of concrete structure was published in 1905 * in which it was shown that when drying oils like China wood oil and linseed oil were combined with a resin acid, the lime in the concrete was acted upon and an insoluble lime compound was formed.

Practically all of the good cement floor paints which are on the market today are based on the principle of the resin acids, and in order to explain the reaction that these acids have upon concrete, it is necessary to know that Portland Cement is a neutral compound before it is mixed with water and becomes increasingly alkaline up to the point of its so-called final set and then remains alkaline to a greater or lesser degree permanently.

While Portland Cement is a true calcium iron and aluminum silicate of a rather complex type, the old Roman cement, which was known as Pozzuolana, formed a mortar with

*813, 841

the same analogy as the Portland Cement to-day. When that natural cement was mixed with water, lime was slowly generated which formed a cementatious material.* Concrete which is porous and exposed to the elements is, of course, likely to be less alkaline than sound dense concrete but the porous type makes a better foundation for painting and decorating. All of the samples of old Portland Cement concrete that have been examined still show alkalinity even though it be very faint unless it has been exposed through its own porosity to the leaching action of water. How long this alkalinity subsists it is difficult to say, but the chances are that it will be in this condition for many centuries.†

* See page 49.

† See page 49.

Methods of Neutralizing the Lime in Portland Cement Concrete Previous to Painting

AN ENORMOUS number of methods have been suggested for the neutralization of the lime in concrete so that it does not destroy the superimposing coats of paint, and while I do not pretend to give them all, the various ones I give will indicate the types that have been in use and due notice will be given to those that are still in use. The first methods employed were by means of coating with silicate of soda. While theoretically this should have worked out successfully, practically it ruined any paint that was applied over it. The action of silicate of soda on Portland Cement is to precipitate an amorphous type of silica in the pores of the cement, but caustic soda was liberated during this reaction and this caustic

naturally destroyed any paint that was applied.

It was, therefore, recommended that the structure, after coating with silicate of soda, be washed with vinegar or weak hydrochloric acid. This of course meant the use of an additional material and an additional labor cost, but never was quite successful in view of the fact that unless a third labor cost was added to remove the resulting salt, poor results were obtained.

The next method was the use of zinc chloride, but this produced calcium chloride as a by-product which was equally fatal to paint. Alum was suggested and whereas it was found that one kind of alum did the work fairly well, it was found that another type of alum did not work so well. The word alum does not indicate what the chemical matter is because painter's alum may be a sulphate of alumina and potash, whereas paper maker's

alum might be a straight sulphate of alumina without the potash, but with a slightly acid reaction. Paper maker's alum is much better, therefore, than the other type of alum, but unfortunately the solution must be made in hot water with five or six pounds to the gallon before it has an effect.

There are a large number of other chemicals that have been suggested, but the ones that are in vogue today are zinc sulphate and the various types of the fluosilicates. Zinc sulphate works very well if four pounds are used to a gallon of water, which is equal to a 50 percent solution.

It has, however, the detriment that no one knows how much free lime any given Portland Cement structure may contain; therefore, four pounds was suggested so that there would be enough to neutralize. The reaction is simple, a double precipitate being formed of zinc hydroxide and calcium sulphate. This surface

Simple application of all types of water soluble liquid hardeners of the fluosilicate type.

Concrete roof of a factory eroded by acid fumes, which could have been prevented had the concrete been properly painted.

must be allowed to stand at least twenty-four hours and if the weather is favorable, and the structure dries out, the excess sulphate of zinc forms efflorescence, and unless this is removed, it ruins the paint.

By far a better material to use in the neutralizing of cement structures, where such neutrality is essential, is an efficacious application of a chemical known as the double fluosilicate of zinc and magnesia.* The reaction of this chemical compound is exceedingly interesting. It does not precipitate the amorphous type of silica, but precipitates the colloidal type of silica and the zinc precipitates the zinc hydroxide.

While this produces a whitish scum the day afterwards, it can very easily be removed and it must be removed before painting. It hardens the face of the concrete to such an extent that a comparative test made between

* This material is known commercially as "Flintox."

the treated surface and the untreated surface with a chisel or a file shows barely a scratch where the concrete has been treated, and shows a deep scratch where the concrete has been untreated.

There are many cases, such as kitchen floors and public buildings, where this is the only treatment that is necessary and where for decorative purposes or for the purpose of giving a uniform effect, an oil aniline may be used to stain the floor. The most rational and perhaps the most successful method that has been in use since 1903 is the acid resin method mentioned in the beginning of this chapter, which is particularly effective for floors where the fluosilicates are omitted.

All the oils used in the manufacture of paint and all of the natural resins are acids. This is not generally known and is the basis of the successful painting of cement concrete. The reaction is not immediate; it is very complex

and sometimes takes considerable time, but it only occurs in the presence of a slight amount of moisture. It is not generally known that all of the oils in drying generate, in addition to carbon dioxide, a small but steady amount of water and it is through this liberation that the acid of the resin and the lime of the concrete form what chemists have been pleased to call a tungate and resinate of lime. This material becomes exceedingly waterproof and very hard, and when properly proportioned, gives a protective coating both for interior and exterior that has served its purpose exceedingly well.*

The application of a protective coat on a

* One of the most successful materials of this type has been marketed for many years under the name of Koverflor. The material which was made under the first patent 813, 841 was used in the control locks of the Panama Canal where the abrasion of the silicious particles of the cement floor would have been very deleterious to the contact points of the expensive electrical machinery which was installed. In these entire locks 250 barrels were used in 1915.

floor or a wall in the interior of a building, while similar in principle to exterior painting, is nevertheless different both as to composition of material and application. It is sometimes very difficult to paint an interior floor which has a hard troweled surface and in that case either the clear acid solution is used, which is known as Cement Filler, or the acid resin paint is used diluted with a suitable solvent like turpentine or toluol until it is in the nature of a thin wash. Anywhere from 25 to 40 percent of toluol should be used. This enables the acid resin varnish to penetrate as deeply as it can, and the deeper it penetrates, the better the adherence of the second coat.

In the painting of exterior concrete, the action of the elements—rain, snow, hail, dust and fog—are destructive agents of paint. A definite type of second coat must be used in order that the decorative or protective concrete paint shall last as long as possible.

On all exterior surfaces it is much better to use fluosilicate of zinc and magnesia as a neutralizing agent than sulphate of zinc because the resulting efflorescence or crystallization is so much less in the case of the former than the latter. The priming coat is usually sold in a reduced form and there is never much harm in thinning with either turpentine or toluol, and while painter's naptha and painter's benzine are very much cheaper, the penetrative power of turpentine and toluol are much greater, and under no circumstances should benzol, which is an excellent solvent, be used because the fumes of it are poisonous, whereas the fumes of turpentine and toluol are non-toxic.

In the second coat, where long life of the film is desirable, the acid resin varnish pigment is further diluted with oils like Perilla and heavily bodied linseed. The heavily bodied linseed must not be of the blown type but always of the stand oil type, the latter

being a slowly cooked oil, very viscous, but very permanent.

This practically describes the two methods of protecting both interior and exterior of the concrete construction of the painting type, but inasmuch as only a limited number of pigments and a limited number of oils and resins are suitable for the purpose, a description of these is in place.

The pigments used in both priming and finishing coat of concrete must be alkali proof against lime, and those used on the exterior of a concrete structure must be ultra-violet light proof in addition. Most of the white pigments are suitable for this purpose with the exception of the titanium pigments for the reason that these have an influence on all of the oils, and in a short time they chalk very badly.

A small percentage of this pigment has no deleterious effect, provided it is mixed with a larger percentage of zinc oxide. Lithopone

is also of doubtful value, for while it may be light proof, it is not chemical proof and has a vulcanizing action on the oils that affects them like the titanium pigments, but in a lesser degree.

The United States Government battle-ship formula, which is 60% of zinc oxide and 40% of blanc fixe (precipitated barium sulphate) does not chalk and when tinted with pigments that have a high degree of hiding power, makes a very suitable base for the finished paint. The best, however, is the type of leaded zinc, which contains 35% of sulphate of lead and 65% of zinc oxide, reduced with about 40% of precipitated barium sulphate.

If spar varnish, or any acid resin varnish is used to a large extent in the finishing coat, care must be observed that these basic pigments containing a large amount of zinc do not combine with the varnish and form what is known as a liver or jelly.

The safe pigments used for tinting are as follows:

All of the iron oxides such as

Ochre
Sienna
Indian Red
Bright Red Oxide
Spanish Oxide

The Greens

Chrome Oxide and
Green made from ultramarine blue and cadmium yellow

The Reds

Fire Red made from toluidine
Fire Red made from chlorinated paranitraniline
Alizarine Lake

The Blacks

For making bluish grays and neutral tints Lamp Black or Graphite should preferably be used.
Carbon Black, unless very finely ground, is liable to streak.

The pigments that must be avoided and

Concrete building being painted with an acid resin paint, both for decoration and protection.

Steel reinforcing bar which rusted under the concrete, due to its porosity, and which split off the concrete face. There are hundreds of examples like this which prove conclusively, concrete does not prevent rust and under certain conditions, accelerates it.

It is a moot question whether the bar should be painted, or whether the concrete should be painted.

Stucco highly magnified, showing sponge-like openings which tend to the erosion of concrete.

Applying finely divided metallic iron with a brush to waterproof concrete from the interior.

which are acted upon by alkali that might seep through, are

All of the Copper colors such as:

Carbonate of Copper
Paris Green
Emerald Green

The Yellows that must be avoided are all of the Chrome Yellows. They either bleach or turn to a brown shade and are affected by alkali.

The Reds that must be avoided are the iron oxides and Venetian reds which contain calcium sulphate.

As the oil or varnish perishes, the calcium sulphate leaches out as it is soluble in water, about 1 to 700.

The Greens to be avoided are the Chrome Greens made by mixing Chrome Yellow and Prussian Blue.

The Blues to be avoided are

All of the Iron Blues such as

Prussian Blue
Chinese Blue
Milori Blue
Antwerp Blue

Where the brilliant red lakes are to be substituted for other bright colors, the cadmium selenides may be used, which range from scarlet to a dark ruby.

Protection of Concrete in Chemical Works

IT IS never advisable to paint floors in chemical works and factories, particularly where acid and alkali prevail, and where the floors are frequently flushed with water. The best treatment on floors of this kind is to supersaturate them once or twice a year with the fluosilicates.

Concrete can be largely used for the storage of chemicals. It need not be painted with any decorative paint but the protective type, which, made with a very high grade bitumen of the gilsonite type, fluxed with China wood oil. This gives most excellent results.*

There are many chemicals which are decidedly acid like nitre cake. Nitre cake, which

* Patent 802,670

is acid sulphate of sodium, contains approximately 30% of free sulphuric acid and would decompose any type of concrete in a short time with which it comes in contact. Such bins must be coated successfully with the bituminous China wood oil coating previously described.

In paper mills, laundries and factories of that kind, where hypochlorites are used, it is not advisable to protect the concrete with anything but the fluosilicate of zinc and magnesia. Brick walls and cement mortar joints should, however, be coated with paint or filler, and if a decorative effect is desired, an acid proof white paint may be used over a clear coat of Cement Filler.

In order to test concrete as to whether it is strongly or weakly alkaline, phenolthalein can be used as an indicator. When phenolthalein is dissolved with alcohol it is a clear water white solution. If it comes in contact with moist lime it turns a brilliant purple red

but this reaction does not take place unless the wall is moistened with water. Any alkali coming in contact with colorless phenolthalein changes it into a brilliant colored coal tar dye. The brilliancy and depth of the color is usually an indication, relatively, of the amount of alkali that a wall may contain. The proper amount of Cement Filler will slowly discharge the color until it becomes very pale yellowish brown showing that it has been reversed toward its original composition.

Many concrete structures in which the reinforcing bars are near the surface corrode and throw off the shell of concrete. Illustrations accompanying this show how the concrete has been disrupted and this can always be prevented by coating the concrete with a waterproof paint of the acid resin type.

In chemical works reinforced concrete roofs have collapsed owing to the corrosion of the steel in the concrete, but if the concrete is thor-

oughly sealed with the proper type of paint so that air and moisture are completely excluded, corrosion does not take place.

There is an old tradition that steel in concrete need not be painted inasmuch as the concrete is a preservative and prevents the corrosion of steel. This statement is not correct because corrosion of steel in concrete is a very common occurrence. It is due to the fact which has been shown by J. Newton Friend, Toch, Arnold and others, that when the alkali is below a certain percentage—perhaps one-tenth of one per cent, lime does not prevent rust, but in fact accelerates it. This is a moot question among engineers, and probably ever will be, that steel and concrete should not be painted; that even if the steel be rusty when the concrete is placed, the rust has disappeared and the bright steel remains.

Chemists know of course that rust and concrete will form calcium ferrite but this reaction

cannot take place near the surface where there is insufficient lime to complete the reaction. Engineers have always feared that painted steel might slip in concrete. Perhaps this is true of a perfectly round polished bar, but it cannot be equally true of a deformed bar, which in every case produces a mechanical bond.

Where engineers are averse to the protection of steel in concrete, they should under all circumstances see that the exterior is coated with one of the types of paint described in the foregoing pages, which completely exclude air and moisture.

Almost every pigment added to Portland cement for decorative purposes has either a weakening, neutral or strengthening effect on concrete. Some pigments are ruinous to concrete.*

* Transactions American Concrete Institute, February 24, 1925.

Without going into lengthy details of 7-14-29 day results, it is sufficient for the consumer to realize that if Atlas White Portland Cement is used as a standard, the following results are stronger, weaker or neutral.

Yellow Zinc Chromate materially reduces the strength of concrete.

Lead Pigments, such as White Lead and Chrome Yellow weaken cement

Ochres containing 20% and more ferric hydroxide, neutral

Carbonate of Copper Green, very weakening effect

Chrome Oxide, neutral

Chrome Oxide and Ultramarine Blue, slight increase

Lithol Fire Red, Organic Lake, neutral

20% Paranitraniline, 80% Blanc Fixe, neutral

Venetian Red containing between 30-40% Calcium Sulphate, very weakening

Iron Oxides 90% and other Fe_2O_3, slight increase

Turkey Umber containing Manganese, slight increase

Stucco and concrete building painted for protection against leakage and for decorative effect.

Marble pilasters seventy-five years old in the city of New York, which show erosion due to the acid condition of the air.

Outdoor pulpit made of marble twenty-five years old, showing the erosion of the faces due to the acid condition of the air.

Parapet wall of a stucco bungalow built on hollow tile in which the painting of the interior of the parapet wall was omitted and allows the moisture to penetrate the building.

Deterioration of a concrete plaster showing wet spots after a rain.

Dark Gray composed of Mineral Black and Manganese, considerable increase

Dark Slate containing Carbon Black and Manganese, slight increase

Ultramarine Blue free from calcium sulphate, increases strength of concrete over 70%

It is not known what produces this remarkable effect on the compressive and tensile strength of Portland cement, nor does every type of Ultramarine Blue give this peculiar reaction. Ultramarines containing calcium sulphate have a direct opposite effect.

Iron Oxide containing from 10-15% of normal silica, slight increase

Two per cent Carbon Black, weakening effect

Lamp Black, neutral effect first month; slight increase in three months

Cadmium Yellow, neutral

Chrome Hydroxide, neutral

Artificial Iron Oxides of the so-called Mars type, slight increase.

Practically all of these pigments can also be used for decorative purposes when mixed with a suitable type of varnish and oil as a protective coating on Portland cement structures.

Mono-Chromatic and Poly-Chromatic Decoration of Concrete*

CONCRETE can be decorated by various methods to simulate corroded copper, antique brown, rusty brown and many other shades, to give it the patine of age. These staining and chromatic effects of concrete have been used for many years, and when the material employed as a stain has no weakening effect on the concrete, it sometimes serves an effective purpose. Where it has a weakening effect, as for instance, in the case of imitation corroded copper, and the product produced is used as a wall tile, or in fact, for any decorative purpose excepting a floor or a column where compressive and tensile strength play an important part, the decoration of concrete by

* There are a number of patents covering dyes and their applications, which relate to the coloring of concrete.

means of chromatic methods will not produce any bad results.

The types most in use are:

1. The alkali-proof lakes which are mixed with the concrete while it is still wet, sprinkled in and roughly troweled. These, with the exception of the para-nitraniline and the lithol lakes are more or less fugitive, and should not be used where exposed to the direct sunlight.
2. Another method used is the employment of the ordinary varnish stains, the same as are used for staining wood, but for this purpose poor and porous concrete gives really a better appearance than a dense, rich concrete, for after all, concrete properly made is impermeable. The wood stains are always applied after the concrete is at least seven days old.
3. The third method of producing a patine of age is produced by sprinkling small and irregular amounts of mixtures of iron filings and ammonium chloride on the structure within an

hour, and before the surface has been troweled. When this is kept copiously wet for the greater part of a week, the ammonium chloride rusts the iron and produces streaks, and irregular patches, which finds favor with some decorators.

4. The next method for producing the same effect is by the use of either ferrous sulphate or ferric chloride. Ten or twenty per cent solutions of these iron salts are mixed with the concrete and on setting, the concrete obtains a streaked rusty appearance. Incidentally, both of these materials increase the compressive and the tensile strength of concrete.
5. Another method used for the production of variegated shades, is by the application of two separate solutions, which interact, and form a precipitate. As for instance, the verte antique effect produced by mixing copper sulphate and ammonium carbonate. A reddish-brown effect is produced by the use of ammonium or sodium sulpho-cyanide and a ferric salt like chloride of iron.

In most cases it is advisable to coat the structure so stained with an acid resin cement filler which changes the refractive index and brings out the color to a considerable brilliancy.

6. Equal parts of dry cement and equal parts of permanent cement colors are mixed with water and dashed on the setting concrete and then rubbed in. This produces a variegated marbled effect which is very permanent.

Painting Cellar Floors

PAINTING floors that are built both for protection against moisture and for decorative purposes, is often done in houses near the seashore, particularly in a State like Florida where there are no cellars. Most of these results are disastrous. The reason for this is plain.

In order to save money, builders put down 6″ of broken stone or rock of some other kind, on top of which is a 1:2:4 mixture. Then, on top of this is placed a ¾″ topping of 1:2 or 1:3 cement grout, troweled down hard. As the rain becomes capillarily attracted under the floor, the surface becomes alternately wet and dry. Thus all applications of paint seem to be futile. Therefore, a painter should not attempt the painting of a floor which is built directly on the ground.

In new construction this can, of course, be overcome by building a floor of this kind on a solid, membrane-waterproofed application and turning it up at the edges so that there is no danger of capillary attraction of moisture or seepage into the cellar floor. Such floors, it is true, can be painted and decorated; but where they are continually wet, copious applications of fluosilicate of zinc and magnesia will eventually harden them and make them dense as well as waterproof, so that in time they can receive a clear coat of Cement Filler.*

* Cement Filler in every case must be the acid resin type of varnish, with sufficient diluent to make it penetrate.

Decoration of Concrete and Wall Plaster

THE atmosphere of any great city is both corrosive and erosive. The accompanying illustrations #6 and #7 show what happens to marble exposed to the elements for twenty-five years. Faces have been eroded and the fine carving has practically disappeared. Illustrations #8 and #9 show what happens to marble construction seventy-five years old, and as these ravages are progressive, it is only a question of time when building construction which is subjected to atmospheric influences is eventually destroyed. A chemical analysis shows that this is due largely to the sulphuric acid in the atmosphere. Coal and oil are sulphur-bearing and the smoke is converted into sulphuric acid and the amount that hangs over

Showing the cracking of concrete through which lime is liable to leach in a rain storm and destroy the paint. These cracks cannot be filled up with paint unless they are less than 1/16" in size. They should be filled up before repainting with an elastic corking compound which adheres to concrete, if possible.

Cracks in a concrete window sill and a space between the window frame and the window sill which accounts for moisture on an interior wall due to driving rain. Such a defect can best be remedied by caulking the window frame and painting the concrete with a waterproof cement paint.

Corner of a concrete building which shows water logging due to minute cracks.

A White Terra Cotta Tile Building, partially cleaned, showing the effects of smoke and dust in the atmosphere of the City of New York.

a city like Pittsburgh and New York, sounds like an astronomical figure.

The colorless waterproofings are the nearest approach to a solution for the preservation of building materials, but they have to be applied every few years. Some of these colorless waterproofings are, however, very weak and many contain less than 6% of solids. These, of course, do not protect building material for any great length of time. A good colorless waterproofing should contain more than 13% of solids and show very little stain.

Paraffin wax impregnated into concrete or building material is never to be recommended because the highest melting point paraffin is liquid at 136° F. and begins to run and seep at much lower temperatures, always attracting dust and dirt which is practically impossible to remove.

Ceilings of buildings which are composed either of concrete or of plaster should always

be treated with a material like Flintox* and then receive a coat of an acid resin varnish like Cement Filler. (See p. 16.)

Nitrocellulose lacquers are affected by sunlight and usually turn yellow. They have, therefore, not been very successful as an exterior colorless waterproofing, but for interior walls, particularly sandstone and concrete finish, a spray coat of lacquer gives a satin finish which can be washed with soap and water and kept in continually good condition.

Where a slight discoloration of brick makes little or no difference, the colorless waterproofings to which a small percentage of pale China Wood Oil is added, give very good results.

Mineral colors which are supposed to be absolutely permanent are not all as good as the chemical colors, as for instance, Azurite and Malachite are not by any means as reliable as artificial Ultramarine Blue and Chromium Hydroxide.

* Fluosilicate of zinc and magnesia.

Influence of Atmosphere

TAKING the atmosphere of a city like New York as an example, and this probably refers to the atmosphere of every great city, the air is laden as I have shown previously, with coal smoke and traces of sulphuric acid. A concentration, however, of the actual amount of sulphuric acid contained in the atmosphere of the city of New York would amount to thousands of tons, and the effect, as has been shown on marble structures, is cumulative. In addition to these gases, the results show an enormous amount of solid matter, an analysis of which indicates that it is composed of organic matter, silicious substances and both metallic iron and oxide of iron. The silicious matter originates through the traffic over the pavements of New York, but the metallic iron

and iron oxides are very readily traced to the dust that comes out of the subways and finds its origin from the grinding of the wheels against the brakes. In fact, an analysis made by the author several years ago of the dust in the subway, showed it contained an appreciable amount of metallic iron and that it was magnetic. Sprinkled on a sheet of white paper, it followed the movements of the magnet when drawn across the bottom of the sheet.

Illustration (page 39) shows a building that was originally white and that had turned a dark gray, in fact, almost black, in certain places, and the photograph illustrates the cleaning of the front of the building and the absolute strong line of demarcation between the washed and the unwashed. It may be speculative because it has never been proved, but it is the author's opinion that the powerful adherence of the dust of the streets on the surfaces of the buildings is electro-magnetic, because the

adherence of the dust, if it contained no magnetic substance, would be easily removed by each succeeding rainstorm. Not only are powerful solvents necessary to remove this adherent foreign matter, but friction is necessary in addition. Every building contains electric light and telephone wires, and it is not mere speculation to assume that induced currents may hold this dust in place because the examination of any gasholder which contains no electric wires on the inside shows no tenaciously adhering dust or dirt on the outside, and gasholders as a rule are washed clean in a heavy rainstorm and buildings are not. So great is the discoloration and the adherence of dust to many buildings, that in order to renovate them they are frequently sandblasted or washed with soap and water and then a jet of live steam directed against the surface. Acids like hydrochloric acid or diluted nitric acid, known commercially as aqua fortis, are also

used to remove the dirt from the exterior of buildings, and wherever paraffin compounds are used, floating dust and dirt are embedded in the surface. There are, however, instances where melted paraffin is of some benefit and where the patine produced is not objectionable, as for instance on the obelisk in Central Park. This obelisk stood for 3000 years in Egypt and hardly showed the ravages of time, but in less than twenty months it began to disintegrate in the climate of the city of New York.

Conclusion

THE painting of concrete is of great importance where it is subjected to the influence of the atmosphere of a manufacturing city, and the foregoing chapters indicate that with a little previous study, the architect, the engineer and the contractor can readily determine the liquids and the materials which are necessary for the purpose. It is safe to assume that the lime on the surface must first be neutralized, but if water should seep through concrete, either from a parapet or from an interior surface or from a hairline crack, it is bound to carry with it a small amount of free lime, for after all it is sufficient to assume that the lime in the interior of any concrete structure, even though it be mortar, remains alkaline or basic indefinitely.

What has been said of concrete is equally

true of lime, plaster or lime mortar, for after all, these are building materials which have a strong analogy to Portland cement, as far as their alkalinity is concerned.

Interior decoration should never be done with pigments that are not alkali-proof, whether they are mineral colors or not, nor must an attempt be made to simulate the old Roman or the 15th Century Italian Buono method, because the atmosphere of the modern Western city is not like the atmosphere of Southern Italy, although even now great factories are belching forth smoke in Italy, which will soon ruin some of the old fresco decorations.

The same common-sense rules which apply to the decoration of concrete should apply to all building materials containing lime, and with the exception of Sorrel Cement (oxychloride of magnesia) building materials do contain lime. Plaster walls which are not by any means

Concrete slab roof 4" thick reinforced, in a chemical works. These were completely eroded after six years due to sulphur gases generated on the inside of the building which were converted into sulphuric acid before they reached the roof.

gypsum walls, but gypsum containing large amounts of lime, react on pigments and oils the same as they do on concrete, and a neutralization of the surface and a sealing, of the construction to be painted, by means of the fluosilicates and acid resin fillers, usually produce good results and form a firm foundation for lasting decorations.

Concrete as well as plaster which must be painted or decorated as soon as possible after it is finished, particularly on interior walls, is often dried by means of an open stove known as a "salamander." A salamander looks like a wicker basket standing on four legs or sometimes it is made of an old iron drum into which large holes are punched. This is filled with coke. The windows and doors are closed and the fuel is ignited. As a matter of fact, on account of the closed room the moisture does not escape but an important chemical reaction takes place which is not generally known,

which is of great benefit. The coke burns and gives off a carbon dioxide and carbon dioxide combines with the lime to form carbonate of lime, which is a neutral white compound exactly like marble. When the doors and windows are opened and the super-heated air is allowed to escape, most of the moisture goes with it and the wall is really neutral. Many builders and painters think that it is the hot atmosphere that has made the plaster or concrete ready for paint application, when as a matter of fact it is the carbonic acid that has done the work.

Before zinc sulphate and the fluosilicates came into general use, it was the custom to spray walls with carbonated water. This, of course, did not react as quickly as the carbonic acid gas because there was too little gas dissolved in the water to complete the chemical reaction.

The silicon esters have been suggested as excellent materials for the neutralization of lime

and closing of the pores of a concrete surface prior to painting. However, these have not yet come into use in America and have only had a limited use in England, but the reports are very satisfactory as to the results. In fact, the addition of pigments to the silicon esters has been used for wall decoration on concrete evidently with good results. ‡

* In 1911 I had occasion to examine officially some of the mortar of the Roman aqueduct about ten miles outside of Rome on the Appian Way. The Roman cement which I chipped out of the interior of the structure was still slightly alkaline and reacted with phenolthalein.

† In 1924 I examimed a number of miles of the Chinese Wall north of Peking. This Wall is built of large ochre colored bricks, each brick measuring 6 × 12 × 18. These bricks were laid in a mortar composed of pure magnesia and lime. An analysis which I made at the time showed it to be practically fifty percent of magnesia and fifty percent of lime and the origin of this mortar was traced to the marble of the locality. Some pieces which I collected were tested for alkalinity and whereas this wall was started 3500 years ago and finished about 2600 years ago, the mortar is still alkaline in the interior of the wall.

‡ There are several English patents covering this material. American Patents Nos. 1561988; 1585103; 1607762.

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